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Review of Transit Data Collection Techniques

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Review of Transit Data Collection Techniques

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FOREWORD

One important element of transit planning is the collection of data on the performance of existing services. The collection of these data is the first step in the development of service improvements.

The purpose of this report is to document the common data collection techiques that are used by transit systems in operations planning. The methodologies and applications of the nine leading manual collection techiques are described in this report. We believe this report will be a valuable resource to persons who are new to transit planning.

Additional copies of this report are available from the National Technical Information Service (NTIS), Springfield, Virginia, 22161 at cost.

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We wish to acknowledge the assistance of numerous transit systems in lending insight to their data collection techniques and applications. A special word of thanks is extended to three individuals who provided us with detailed information on their data collection activities -- Ms. Pilka Robinson, Sacramento Regional Transit District; Mr. Angelo Figone, San Francisco Municipal Railway; and Mr. Gary Hufstedler, Dallas Transit System.

We would also like to thank the members of the study review panel for their assistance and contributions. The panel members are:

- Mr. Philip Braum - Metropolitan Transit Commission, St. Paul, Minnesota
- Mr. Jerry Dow - Municipality of Metropolitan Seattle, Seattle, Washington
- Mr. John Sajovec - Southeastern Michigan Transportation Authority, Detroit, Michigan
- Mr. Gary Spivak - Southern California Rapid Transit District, Los Angeles, California
- Mr. Robert Stanley, Urban Mass Transportation Administration, Washington, D.C.

Finally, we express our appreciation to Mr. Brian E. McCollom, our UMTA Project Director, for his assistance in guiding the project, reviewing the draft manual, and making thoughtful suggestions for its improvements.

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CHAPTER 1 -- INTRODUCTION

Almost every transit system today has established a series of data collection practices to support transit operations planning in a systematic manner. The techniques and approaches used vary significantly -- some systems perform cursory reviews of bus service utilization and performance infrequently and others employ rigorous bus service monitoring programs on a routine basis. The need for pertinent ridership and service performance information is becoming all too obvious to transit planners expected to meet public transportation needs with constrained or diminished financial resources. This document is intended to assist transit planners in obtaining required service data by documenting a variety of commonly used data collection techniques which support service planning activities.

1.1 REPORT OBJECTIVES

The purpose of this report is to document the common data collection techniques used by transit systems in operations planning. In a sense the document is an update of the 1947 publication of the American Transit Association entitled "Manual of Transit and Traffic Studies". It differs from this publication in that the emphasis of this report is on data collection for transit operations planning and the original manual's attention to traffic data is not emphasized. Many other local agencies, such as the public works department or metropolitan planning organization, collect traffic information and make it available to transit systems as needed.

The focus on this report is on how to collect commonly needed service planning data. The purpose, mechanics, and output of a variety of manual data collection techniques are described in this document. The guidelines provided herein can be complemented by many other reports which describe data use and the development of a comprehensive data collection plan and program. In particular, the Bus Transit Data Collection Design Manual (1985, Urban Mass Transportation Administration) is a good reference on the design of statistically based data collection programs.

1.2 REPORT CONTENTS

This report explains the methodology and application of nine leading manual techniques used by the transit industry today. Chapter two provides a generic set of guidelines outlining the preparatory steps which facilitate successful data collection. These include technique selection, development of forms and procedures, and observer training.

Chapter 3 then reviews in detail the benefits and requirements of each of the techniques.

- Ride Check - detailed information on passenger volumes along a route, particularly boardings and alightings by stop.
- Point Check - passenger loads at specific checkpoints in the system.
- Boarding Counts - passenger boardings on a route distributed among the different fare categories.

FIGURE 1-1 -- DATA CAPTURE EFFICIENCY

Data Item \ Technique	Ride Check	Point Check	Boarding Count	Farebox Readings	Revenue Counts	Speed and Delay	Running Time	Transfer Count	Transit Vehicle Passenger Stop
Passenger Load Vehicle	●	●	○	○	○	○	○	○	◒
Passenger Trips	●	○	●	◒	○	○	○	○	○
Passenger Miles	●	○	○	○	○	○	○	○	○
Actual vs. Scheduled Arrival	●	●	○	○	○	●	●	○	◒
Boardings and Alightings	●	◒	○	○	○	○	○	○	●
Cash Fares / Trip	○	○	●	●	○	○	○	○	○
System Revenue	○	○	◒	●	●	○	○	○	○
Boardings By Fare Category	◒	○	●	◒	○	○	○	○	○
Transfer Rate	◒	○	●	◒	○	○	○	●	◒

Legend:

● Information which is typically collected in the technique

◒ Information which can also be collected in the technique with some additional effort

○ Information is not readily obtainable by the technique

- Farebox Readings - running total of cash deposited by passengers on a particular bus.
- Revenue Counts - the amount of money collected by the transit system.
- Speed & Delay Study - identification of impedances to transit vehicles along a route or corridor.
- Running Time Check - average travel time required by vehicles in revenue service for routes or route segments.
- Transfer Counts - the amount of passenger interchanges occurring between routes.
- Transit Vehicle Passenger Stop Study - the boarding and alighting characteristics of particular bus stops.

Each is discussed in separate sections of Chapter 3. A brief summary of the techniques is included in Chapter 4. This last chapter also identifies other relevant data collection references.

A review of these techniques will show some apparent overlaps in the data being collected. For example, schedule adherence data can be collected in several techniques, including ride checks, point checks, and passenger stop studies. Although the primary focus of these studies is typically on passenger boarding or loading activity; schedule adherence data can be collected with some additional effort. The typical and additional data elements which can be captured using the nine data collection techniques are identified in Figure 1-1 and can be used to corroborate or update one technique's results with the findings of another.

Many of these techniques are conducted as part of a transit system's routine data collection plan (e.g., ride checks, point checks, and farebox readings). Once used to establish an information baseline, either the basic or the optional data collected could be used for periodic updating and analysis. Similarly, a few of the techniques are conducted infrequently or on an as-needed basis. The results of one technique may serve as the catalyst for conducting an additional study (e.g., boarding counts may suggest the need for a transfer count).

1.3 REPORT USE

This report is intended for use by the staff at transit systems who collect, monitor, and analyze ridership and revenue data. Each technique described in Chapter 3 is presented in a standard, four-section format:

- Purpose - why and when the technique is used and a concise list of information which can be obtained;
- Procedure - step-by-step instructions for application;
- Data Collected - a discussion of the basic and optional data items which are collected; and
- Typical Data Analyses - instruction on how to aggregate and manipulate the data.

Sample forms for field assignments and subsequent analyses are provided for each technique. These are designed as generic examples and can be used as is or adapted to suit the individual transit system. Each discussion highlights both typical and optional applications of the technique and the captured data.

CHAPTER 2 -- DATA COLLECTION GUIDELINES

In this chapter, several steps which support the planning phase of any data collection program are discussed. The steps are intended as general guidelines, and as such, may be modified as necessary.

2.1 IDENTIFY INFORMATION NEEDS

The impetus for conducting any data collection program is the need for information. Information may be required for internal management reporting, a routine or special service analysis effort, or external reporting requirements (e.g., Section 15 Reports). At the onset of any data collection program, the specific data requirements should be identified. This can be accomplished by answering key questions about the purpose of the study, such as:

- What information is needed?
- What type of analysis is likely to provide the appropriate information?
- What data are needed for the analysis and at what level of detail (e. g., systemwide, route-segment)?
- What time period(s) should be covered?
- What level of accuracy is needed, and what does this require in terms of sample size?

2.2 SELECT DATA COLLECTION TECHNIQUE

The specific data requirements determined above should drive the selection of a particular data collection technique or techniques. In most cases, comparable information can be gleaned through more than one technique. Therefore, it is necessary to evaluate comparable techniques to identify the most appropriate data collection method for the assignment. Several criteria could contribute to this evaluation, including:

- Satisfaction of primary data needs
- Implementation cost and labor requirements
- Administrative requirements
- Additional data available through the technique
- Time schedule

2.3 DEVELOP DATA COLLECTION FORMS

Standardized data collection forms should be developed to capture all pertinent data elements needed for analysis. The field sheets should be concise, easy to use and logically formatted. This report provides numerous sample field sheets in Chapter 3, which can be considered for use in technique application. If aggregation of data is to be completed on the form itself, sufficient space should be provided and steps identified.

While the specific data items to be captured by different techniques varies, some control data may be appropriate for use on all field

sheets. Standard information might include:

- Name of observer
- Day of week
- Date
- Weather
- Route numbers, block numbers, run numbers, and/or street intersection
- Comments or remarks of observer
- Form number

Each of these elements contributes to data interpretation and/or data control. For instance, a significant deviation in ridership and schedule adherence may be the result of a weather condition and not really reflect average route characteristics. A form number is used to improve data control. Sequential numbering of data forms can enhance data collection control by providing an audit trail for form distribution and collection. Upon distribution, the study manager would record the form numbers given to each person by day and subsequently record those turned in at the end of the day. This may help prevent form loss, and serves to monitor observer performance.

2.4 ESTABLISH ADMINISTRATIVE PLAN

The procedures for study implementation should be well defined to facilitate the cost-effective use of time and resources throughout the data collection program. Specific responsibilities, procedures, resource requirements and schedule milestones for the data collection endeavor should be determined.

The formalization of responsibilities for all participants in the data collection efforts can be helpful. Field observers, supervisors, analysts and the program manager should all be aware of their respective tasks. In addition to responsibilities, the study procedures should be documented to ensure comprehension by all involved parties. Procedures might include details such as:

- Reporting place and time
- Observation point
- Data recording procedures
- Supervision
- Data analysis

A brief, written statement of responsibilities and procedures may help in reducing training time and facilitate study comprehension.

Resource requirements should be determined based on sample size and data collection responsibilities. In the area of staffing, it may prove helpful to arrange for a reserve or "extraboard" of observers to cover absences and "no shows". This approach can be particularly helpful if the time schedule is constrained. Other resource requirements such as transportation, supervision, and data collection tools (e.g., stop watches) should be determined and a study budget prepared.

The overall schedule and intermediate milestones are important aspects of the data collection program, and should be identified early on in the plan. Where possible, some flexibility should be built into the schedule.

Uncontrollable delays may occur during data collection, such as inclement weather or service disruptions which skew or reduce the validity of some data. Data collection schedules should include some contingency for change or follow-up should significant concerns arise during the initial phases of data collection.

2.5 CONDUCT TRAINING PROGRAM

A thorough training program should be completed by all data collection personnel prior to implementing the study. The training course can be relatively brief, and should be easy to understand. Written responsibilities and procedures generally help get the message across to observers in training, and can be referred to at a later date.

The observers should be instructed on the best vantage point for observation and on techniques for accurate data determination. Both the order in which data are recorded (e.g., first arrival time and then passenger load) and counting procedures (e.g., count empty seats or standees in peaks) must be clearly defined. The use of any equipment (e.g., stop watches) should be reviewed in training as well.

Data collection forms should be used in the training program to assure that requirements are understood. Procedures for aggregating data and abbreviating occurances must be consistently employed to ensure comparability. Legibility is also an important consideration.

Contingency plans should be reviewed with observers. The data collection personnel should understand the schedule of their employment and notification procedures to be used if rescheduling is required. Observers should be requested to call in if they are unable to participate so reserve staff can be contacted.

2.6 MAINTAIN QUALITY CONTROL

The information resulting from a project can only be as accurate as the raw data collected. It is important to maintain quality controls throughout the data collection activity. A two-step program has been successful for many transit systems. This includes a pre-test and field supervision during implementation.

The pre-test can be conducted on a limited scale prior to full implemenation to examine:

- The performance of observers and the effectiveness of the training program; and

- The efficiency and effectiveness of data collection and recording procedures.

The actual data collected during the pre-test can be used as part of the data base, if acceptable in quality.

During full-scale implementation, supervisors should periodically review the results of the data collection effort on a sample basis. Supervisors can discretely perform redundant counts to compare with observer data to verify accuracy.

CHAPTER 3 -- TRANSIT DATA COLLECTION TECHNIQUES

There are a number of commonly used manual data collection techniques which provide information supporting transit service planning and monitoring activities. Many of these techniques are conducted on a routine basis by transit planning personnel. Other techniques support special programs and are conducted infrequently. This manual describes nine routine data collection techniques including:

- Ride Check
- Point Check
- Boarding Count
- Farebox Reading
- Revenue Count
- Speed and Delay Study
- Running Time Check
- Transfer Count
- Transit Vehicle Passenger Stops

Each of these techniques is discussed below in terms of purpose, procedure, data collected and typical data analyses. Sample field sheets and data compression forms are provided for each study type to facilitate technique use and data interpretation.

3.1 RIDE CHECKS

Ride checks are intended to provide detailed information on passenger volumes along a route. Boardings and alightings by stop are the primary data captured in most ride checks. This information is generally used to develop ridership characteristics by route for scheduling purposes, and also to fulfill certain Section 15 reporting requirements. Patron boarding and alighting characteristics are key factors in most service rationalization and monitoring activities.

Purpose

Ride checks are a vital tool for most transit properties. Valuable information can be attained for various degrees of aggregation -- per trip, per route, per stop, or per time period.

The flexibility inherent in this technique enables a transit property to monitor ridership over an extended period of time, or to capture support information when assessing service changes or developing service plans. Information which can be attained from ride checks can be utilized to:

- Fulfill Section 15 required passenger and trip length data;
- Determine position and duration of maximum load point(s) (see Point Checks);
- Indicate opportunities for turnback service due to inadequate demand;
- Determine which stops could be eliminated or relocated based on demand characteristics;
- Indicate whether a route could be permanently shortened;
- Determine load factors and evaluate vehicle productivity over an entire route;
- Monitor schedule adherence;
- Determine dwell times at each stop;

- Determine running time per route segment; and

- Establish overall ridership travel patterns.

This extensive list illustrates the value of this collection technique.

Procedure

The general data collection guidelines discussed in Chapter 2 can be used to develop the data capture plan. The requirements unique to ride checks are discussed below.

Preparation - The training of observers should include a familiarization with the bus and specification of the best vantage point to monitor passenger boardings and alightings. This is usually the first seat directly behind the driver.

Implementation - One observer is typically assigned to ride each selected vehicle. The observer usually counts passengers as they board and alight at each stop. One observer per vehicle is generally sufficient to collect all data. However, a second observer may be needed during peak periods on articulated vehicles or vehicles with simultaneous two-door boarding and alighting. High volume stops may also require the assistance of an observer at the stop.

Data Collected

The data most readily attainable from a ride check are listed below:

- Bus stop location (name or number)

- Vehicle arrival time at each stop

- Passenger boardings at each stop

- Passenger alightings at each stop

- Dwell time at each stop (optional)

A sample field sheet is provided on Figure 3-1, illustrating the basic layout of the form. A slight modification to this is to pre-print the stop name(s) or numbers on the form. During peak periods, this can reduce the burden on the observer and simplify his collection requirements. If stops are pre-printed on the form, care should be taken to list all possible stop locations, since confusion may result if the bus stops have an unusual location. During the orientation, the observer should be instructed how to handle these unusual situations.

When special ride checks are performed prior to service changes, or if additional information is desired, the field sheet should be modified appropriately. For two particular applications of ride checks, namely schedule performance and dwell time determination, more detailed data on bus stop arrival and departure times are required. A sample form satisfying the information requirements for both of these applications is shown on Figure 3-2.

In the first column of this field sheet, the scheduled arrival time of the bus is documented -- done either before or after data collection. Actual arrival time is then recorded in the adjacent column, simplifying the comparisons of the two in ensuing analyses. The departure time from the stop is recorded in the third column. The dwell time is easily determined by subtracting the arrival time in the

FIGURE 3-1 -- BASIC RIDE CHECK FIELD SHEET

RIDE CHECK FIELD SHEET

BLOCK NUMBER ____________________ ROUTE NUMBER ____________________

DAY __________ DATE __________ WEATHER ____________________

DIRECTION OF TRIP ____________________ OBSERVER ____________________

SCHEDULED START TIME ____________________

Location	Passengers			Time Check	Remarks
	On	Off	Load		

FIGURE 3-2 -- EXPANDED RIDE CHECK FIELD SHEET

RIDE CHECK FIELD SHEET

BLOCK NUMBER ______________________ ROUTE NUMBER ______________

DAY ______________ DATE ________ WEATHER ______________

DIRECTION OF TRIP ______________________ OBSERVER ______________

SCHEDULED START TIME ______________________

Scheduled Arrival	Dwell Time		Stop Location	Passengers			Remarks
	Actual Arrival	Actual Departure		Boarding	Alighting	On Board	

second column from trip departure time in the third column. (Note: If only one of these applications is being implemented, space can be provided on the form itself for the calculation).

The simultaneous collection of both schedule adherence and dwell times may be difficult for one observer to conduct because of the many data items required at each stop. This may result in inaccurate data and thus inaccurate planning information.

Typical Data Analyses

The boarding and alighting data captured in a ride check support a variety of demand and service utilization analyses. Each of these analyses are discussed below within the context of the objectives (e.g., "Purpose") stated at the outset of this section.

FIGURE 3-3

DETERMINE PASSENGER MILES AND AVERAGE TRIP LENGTH

AVERAGE TRIP LENGTH

formula (1) X (2) = (3)

Stop Location	Passengers On	Passengers Off	Passengers Total	Distance To Next Stops (Miles)	Passenger Miles
K-Mart	16	–	16	2.0	32.0
8th/Main	17	2	31	2.2	68.2
12th/Main	28	3	56	1.2	67.2
14th/Main	2	4	54	1.0	54.0
15th/Main	3	25	32	1.1	35.2
CBD Terminal	–	32	0	–	–
TOTALS	64	64		7.5	256.6

$$\text{Average Trip Length} = \frac{256.6 \text{ Passenger Miles}}{64 \text{ Passengers}} = 4.01 \text{ Miles}$$

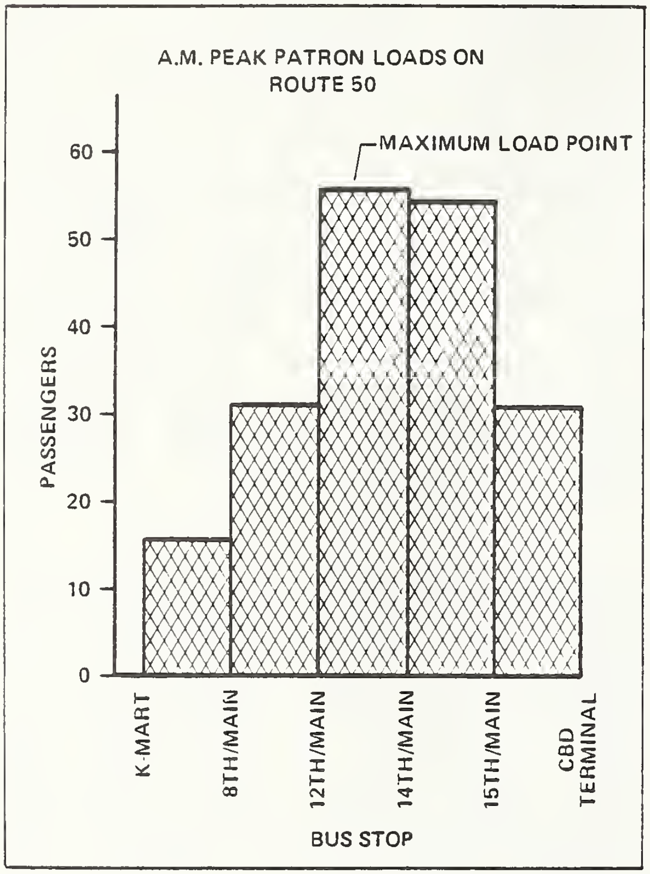
Determination of Passenger Miles and Average Trip Length - Section 15 required passenger and trip length information can be determined from ride check data, through a simple calculation. As shown in Figure 3-3, the number of passengers on board the vehicle upon leaving a bus stop is multiplied by the distance the vehicle travels to the next stop. This yields the passenger miles on that segment of the route. This is then summed over all segments to produce the total passenger miles for the particular trip. This number is then divided by the total number of passengers to determine the average trip length. This approach can be repeated for each trip, if single vehicle or specific time information is desired.

Route Load Profile Analysis - A route load profile analysis is a basic analytic tool used in conjunction with ride checks. Passenger loads are aggregated over all vehicles on a route for a specified time period and route direction. This is done for each segment (between stops) along the route. The passenger load is then plotted against stop location, as shown on Figure 3-4. This provides a graphic illustration of the passenger load distribution per route segment for the particular time period.

This graph can indicate many different things. If prepared by vehicle, a graphic illustration of load factor and vehicle productivity is provided. Also, the point or points along the route where the maximum load occurs is identified -- between 12th and 14th Streets in our example. This information supports service scheduling and also serves as an input to point checks (see Section 3.2), which provide more extensive data for schedule analysis. Similarly, light loads on successive stops at the beginning or end of the route could signify the opportunity for early turnbacks.

FIGURE 3-4

ROUTE LOAD PROFILE ANALYSIS



The development of a passenger load profile for a route can be used to satisfy many informational objectives. In particular, the following can be achieved:

- Load factors can be determined and vehicle productivity can be evaluated over an entire route;
- The position and duration of maximum load point(s) can be identified; or
- Opportunities for turnback service due to inadequate demand can be indicated.

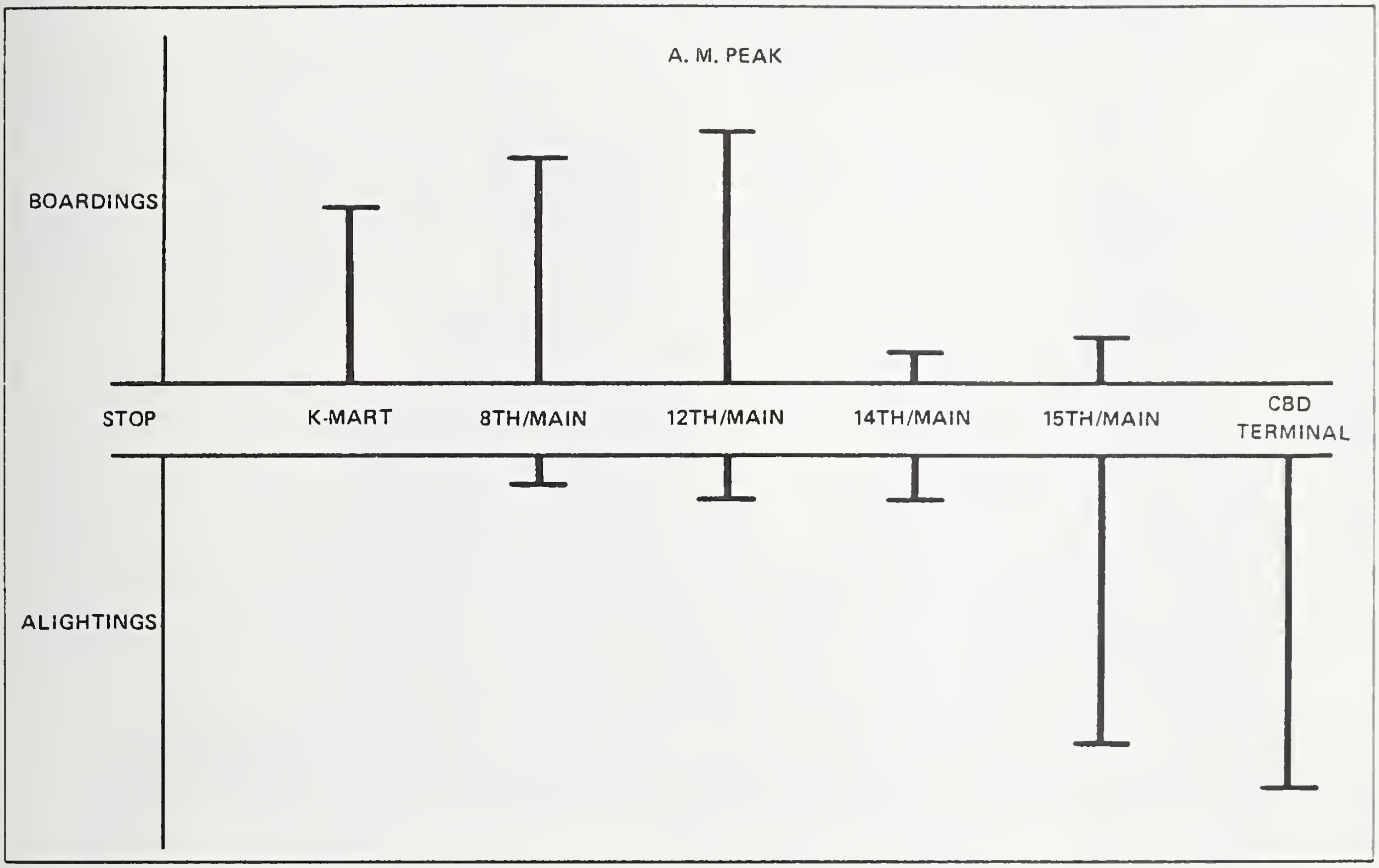
Boarding/Alighting Profile Analysis - A boarding/alighting profile analysis is used for assessing passenger utilization of individual bus stops. This approach is used to identify stops to be considered for possible elimination. This process is similar to the route load profile in that passenger data is plotted by stop location for a particular run or time period. However, the information is used in a more disaggregate form as passenger activities (i.e., boardings and alightings) at each stop are shown independently, as illustrated in Figure 3-5. In the example, the 14th/Main stop is clearly not a major demand point for service during the time period illustrated. If similar results are realized after aggregating the data over many trips and time periods, this stop could be considered for elimination.

Total Passenger Distribution - The daily time distribution of passenger loading along a route illustrates overall ridership travel patterns. The total number of passengers on a route is aggregated over all trips for each hour of the day. This provides a 24-hour profile of the distribution of service demand for the route (Figure 3-6).

This display encompasses the total patronage of the route. Peaks and valleys in ridership levels are clearly indicated by time period. This can support efforts to reduce operating costs by reducing the peak/base ratio. It can also indicate potential service reduction opportunities. The latter is evidenced on Figure 3-6, where the ridership after 9:00 p.m. is very low.

Boarding Time Calculations - If vehicle arrival and departure times by stop are recorded on the field sheet, dwell time can be determined by sub-

FIGURE 3-5
BOARDING/ALIGHTING PROFILE ANALYSIS



tracting arrival time from departure. This information is generally used for evaluating schedule adherence difficulties. Dwell time can be divided by the number of passengers boarding at each stop to determine boarding time per passenger.

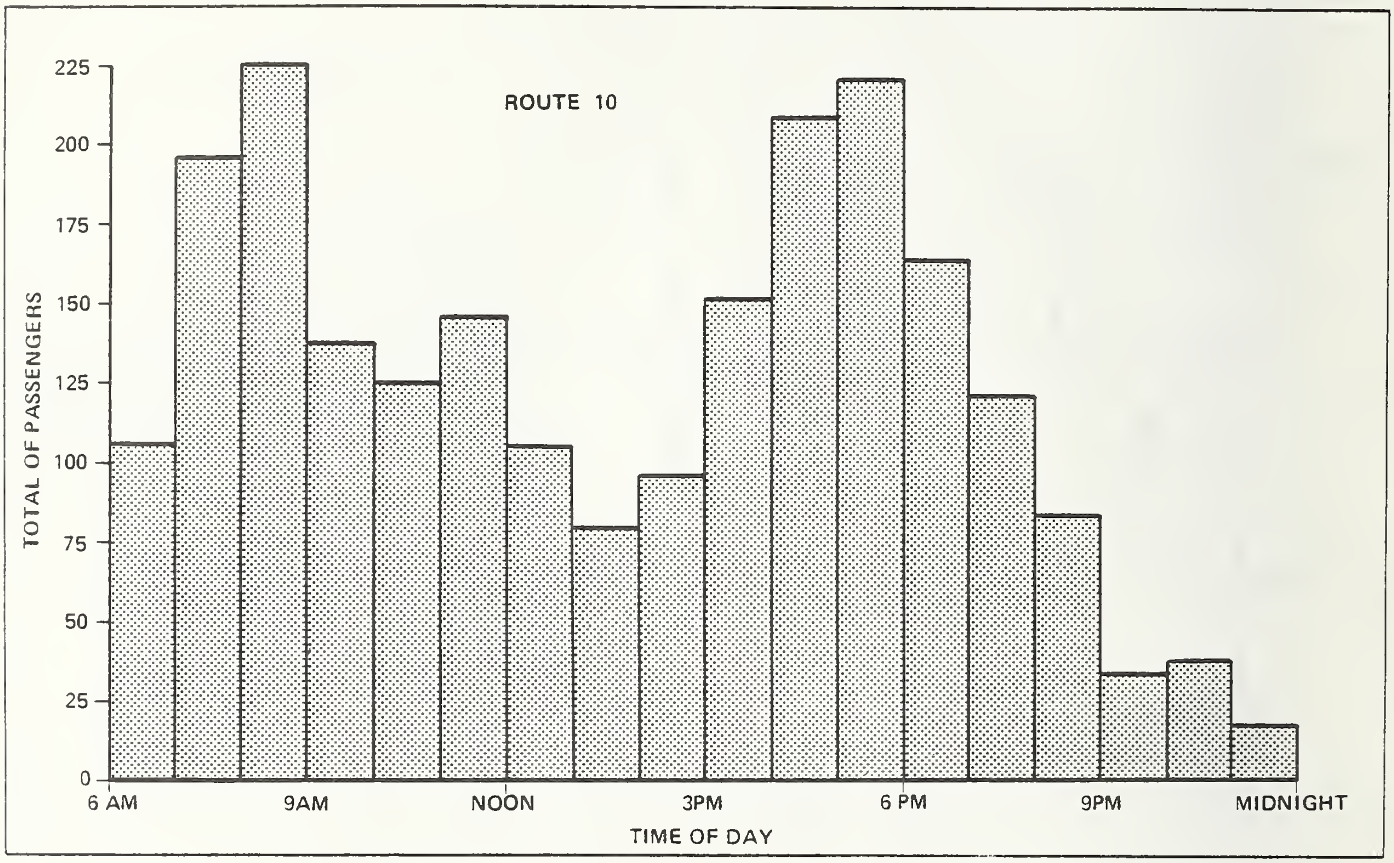
If acceptable schedule adherence performance on a route is not being maintained, dwell time data can provide insights into the causes of delays. A particular application of this is to measure passenger boarding times before and after a change in fare policy or collection practices. A significant change in boarding times, possibly resulting from increased coinage requirements or decreased prepayment utilization, can impact schedule adherence.

Schedule Adherence Evaluation - If vehicle arrival times are recorded at stops or key points along the route during a ride check, schedule adherence analyses can be conducted. A comparison is made of actual versus scheduled vehicle arrival time. Discrepancies can often be explained by examining passenger loading on the trip (e.g., unusually heavy loads cause boarding delays) or vehicle dwell times at the stops.

3.2 POINT CHECKS

Point checks are conducted to establish the passenger load(s) on all vehicles passing a specified point along a route or routes. The information is typically used to support

FIGURE 3-6
PASSENGER LOAD PROFILE
BY TIME OF DAY



scheduling decisions related to service frequencies and sizes of vehicles to be deployed.

Purpose

Point checks can provide an efficient means to determine the passenger load on specified points of a route. This technique is generally used in the development of service schedules.

Point checks can be used for other applications as well. In general, point checks are intended to:

- Investigate passenger complaints of overcrowded vehicles;
- Aid in assigning appropriate vehicle types to various routes;
- Monitor schedule adherence at key point or points along the route;
- Investigate opportunities for or to monitor timed transfers at intersecting route locations;
- Investigate opportunities for early route turnbacks; and
- Determine load factors and evaluate vehicle productivity at a selected point(s) along the route.

As evidenced, point checks are flexible and support many types of service analyses.

Procedure

A point check can be simple to implement and yield accurate and valuable information. Particular requirements for the conduct of this study are discussed below.

Preparation - Observers should be instructed on the techniques of estimating passenger loads. Short vehicle dwell times require quick estimates of seated and standing passengers. Knowledge of seating and standing capacities by bus type is useful for making accurate estimates. One efficient counting approach is to:

- Count the passengers if the bus load is light;
- Count empty seats if the load is moderate; and
- Count standees if the load is heavy.

If fleet vehicles have tinted glass windows, it may be necessary for observers to board the vehicle at the stop. Should this occur, farebox readings may also be taken to determine fare revenue information per round trip.

Implementation - Observers are stationed at selected points in the system. They estimate passenger loads as all vehicles pass, recording the load, vehicle number, and route number. One observer can usually make counts for both directions of a route, and sometimes for several intersecting or over lapping routes. This can be a cost-effective approach to collecting data on a number of routes. However, if many vehicles are passing or loading simultaneously, additional observers may be needed.

Data Collected

The base data recorded in a point check will usually include:

- Route number (or name) of vehicle checked
- Direction
- Block number
- Vehicle capacity (pre-coded on field sheet)
- Arrival time of vehicle
- Passenger load

The passenger load estimate should be taken in a consistent manner for each vehicle checked, either recording the arriving load or departing load. A sample form is provided on Figure 3-7 and shows how observers can indicate which approach was used in taking the count.

When point checks are conducted on a single route, the burden on the observer is reduced. This may provide the opportunity to collect additional data, usually passenger boardings/alightings at the stop. A sample of this modified field sheet is shown in Figure 3-8. It should be noted that the last data column -- "departing passengers" -- need not be recorded during the check as it can be determined simply by subtracting the alightings from the arriving load, and adding the boardings. This calculation need not be made until the conclusion of the point check, or during a lull in activities.

FIGURE 3-7 -- MULTIPLE ROUTE POINT CHECK

POINT CHECK FIELD SHEET

ROUTE (S) ____________________ BUS STOP NUMBER ____________________

DAY ____________ DATE ____________ WEATHER ____________________

☐ ARRIVING LOAD

☐ DEPARTING LOAD OBSERVER ____________________

Route Number	Direction	Block Number	Vehicle Capacity	Arriving Time		Passengers
				Scheduled	Actual	

FIGURE 3-8 -- SINGLE ROUTE POINT CHECK

POINT CHECK FIELD SHEET

ROUTE (S) ______________________ BUS STOP NUMBER ______________________

DAY ______________ DATE ______________ WEATHER ______________________

☐ ARRIVING LOAD

☐ DEPARTING LOAD

OBSERVER ______________________

Direction	Block Number	Vehicle Capacity	Arriving Time		Passengers			
			Scheduled	Actual	Arriving	Alighting	Boarding	Departing

Typical Data Analyses

Point check data can be used to analyze loads on individual trips or can be aggregated by time period to examine average load per vehicle. Schedule adherence data can be used in conjunction with this load information, or can be analyzed separately by individual trip or time period. Several methods for evaluating point check data are discussed below.

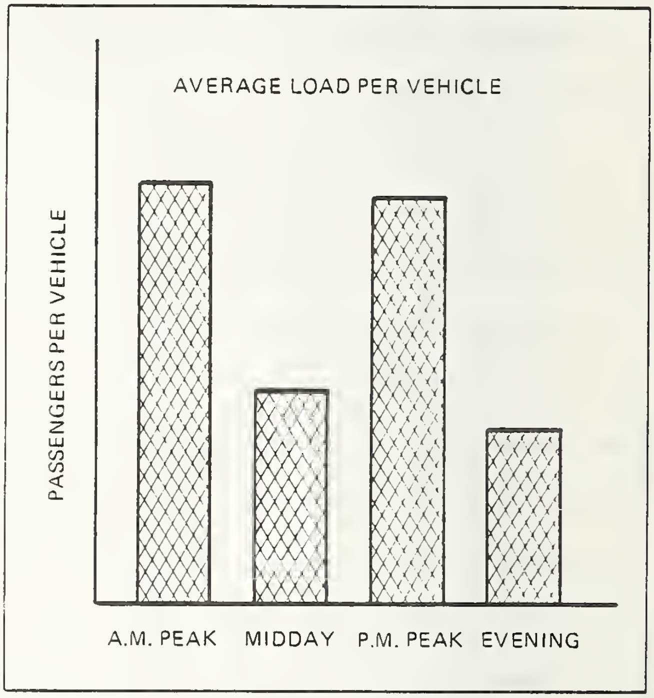
Average Vehicle Load Determination - Knowledge of the average passenger load per vehicle supports many service planning analyses. In particular, the assignment of appropriate vehicle types to various routes is dependent on this information.

The calculation of average passenger load per vehicle is the most common use of point check data. The field data is generally summarized by 15 or 20 minute periods for the a.m. and p.m. peak periods and 30 or 60 minutes for the off-peak periods. Following this aggregation, the average load per vehicle is computed.

Most point checks are conducted at the maximum load point to determine the average load per vehicle for scheduling purposes. This information is used in conjunction with vehicle capacity and the policy load factor to ascertain the headway and fleet requirements for a route.

New point check data should be compared to data from previous checks as a quality control measure. An effective approach for making this comparison is to graph the average load per vehicle for each time period, as illustrated in Figure 3-9. A simple visual aid for pinpointing discrepancies is to overlay this on the previous point check graph or to compare them side-by-side. If significant differences do exist, an additional point check could be used to verify (or refute) the initial results. Changes in ridership volumes along the route could warrant the conduct of other studies -- possible ride checks or on-board passenger surveys -- to explain a substantial increase or decrease in demand.

FIGURE 3-9
AVERAGE LOAD PER VEHICLE PER TIME PERIOD



Passenger Load Per Vehicle - Disaggregate examination of passenger loading (i.e., load per individual vehicle) is useful in assessing vehicle productivity and providing insights into schedule adherence difficulties. Passenger complaints of overcrowding can also be investigated.

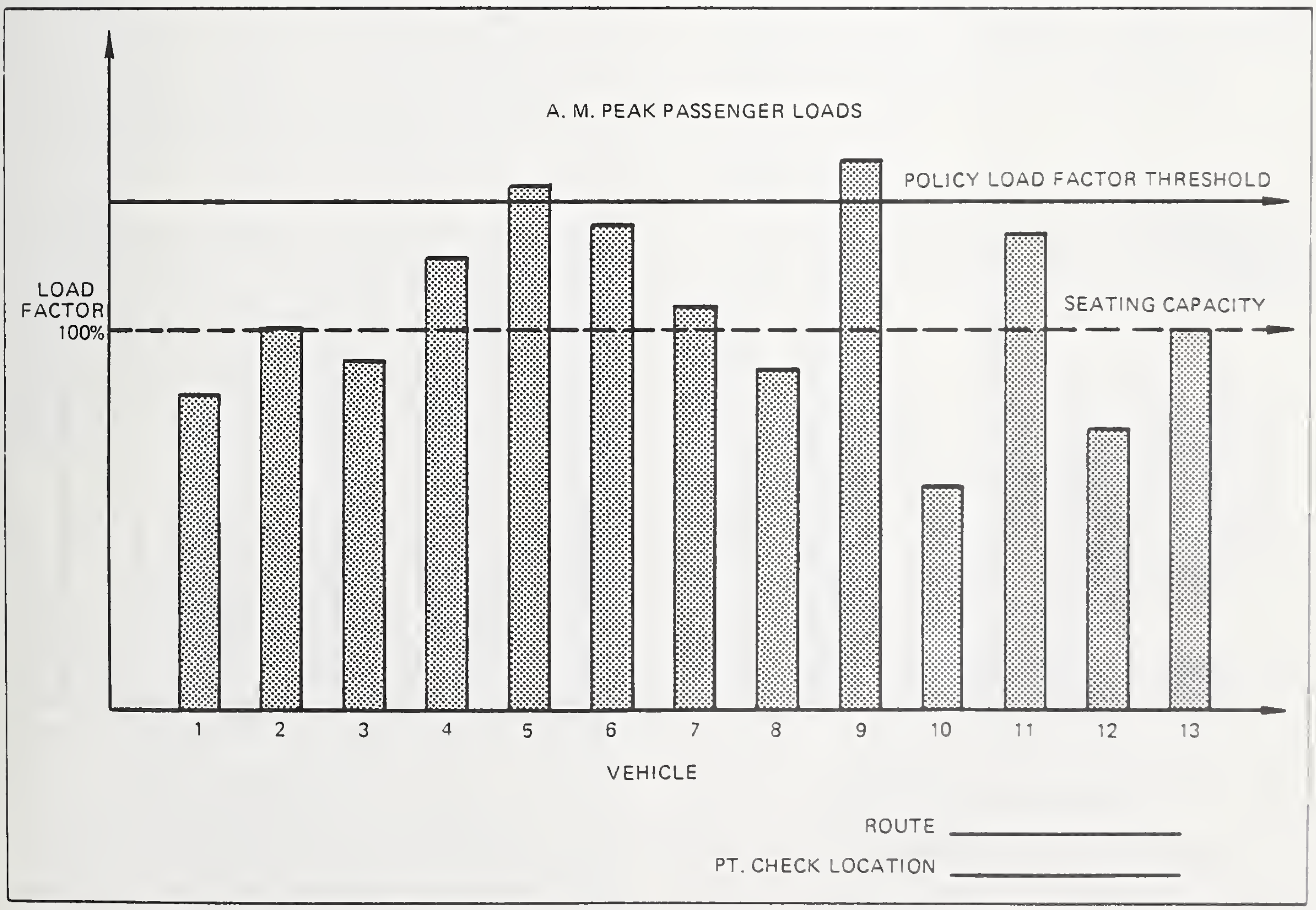
A plot of the individual passenger loads on each vehicle checked is a useful tool, showing the time distribution of passenger demand. If the fleet consists of similar vehicle types, load factors (e.g., passengers / seating

capacity) can be used in place of actual passenger volumes. As shown in the example of Figure 3-10, this enables the simultaneous examination of vehicle utilization and productivity.

Some fluctuation in demand and, therefore, load can be expected. However, excessive variations may indicate that the headway on the route is inadequate, vehicle type (e.g., capacity) is inappropriate, or that vehicles are not arriving at regular intervals (e.g., schedule adherence is not being maintained).

The passenger load for each vehicle can be profiled by actual versus scheduled times of arrival, to address these concerns. Through an analysis of the differences in these times, some insights may be gained behind the fluctuations in passenger loads. For example, in Figure 3-11 the fourth vehicle is slightly behind schedule while the others arrived on time. The fluctuation in load through 7:40 appears to be the result of variations in demand. The vehicle scheduled for a 7:50 arrival, however, was late and probably picked up passengers who

FIGURE 3-10
VEHICLE LOAD FACTOR PROFILE



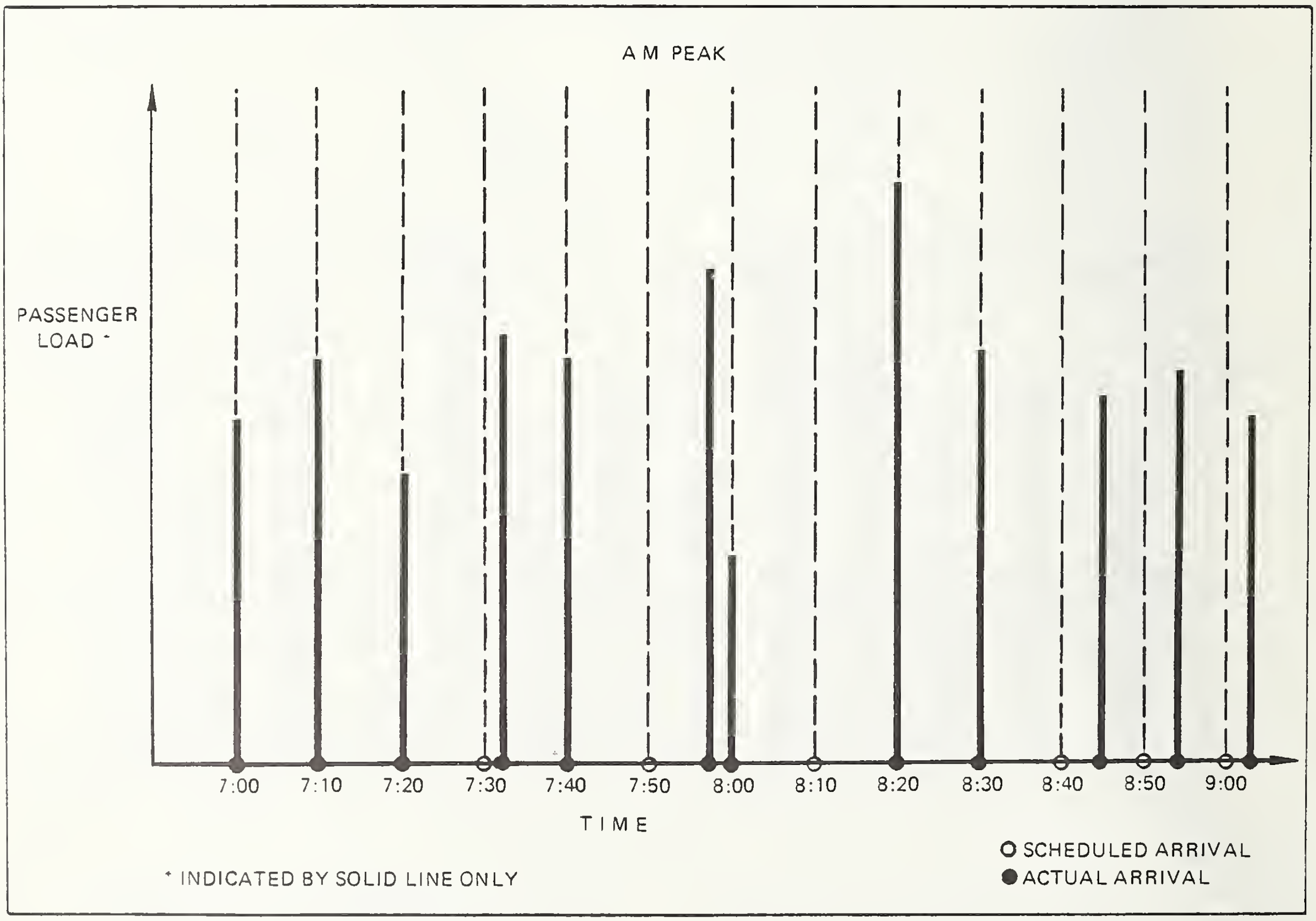
normally would have ridden the 8:00 bus. This may well be the case since the 8:00 bus, which arrived on schedule, had a relatively light load.

The next vehicle on the schedule, the 8:10, was not operated. This may explain the extremely high load on the 8:20 bus.

The last three runs on the profile all arrive late. The load seems to be consistent, however, and it is, therefore, not clearly evident why the vehicles were delayed. Other data collection techniques -- speed and delay study, or running time -- may be used to analyze this problem.

Timed Transfers Analysis - Timed transfer opportunities can be explored or their performance monitored by conducting point checks at intersecting route locations. When the check is conducted at a stop where two or more routes intersect, schedule adherence comparisons can be used to assess timed transfer performance. Depending

FIGURE 3-11
PASSENGER/SCHEDULE ADHERENCE PROFILE



on the number of routes arriving simultaneously, an additional observer or observers may be warranted.

Time or coordinated transfer opportunities are first identified through a transfer count (Section 3.8). Intersecting routes with a high volume of transfer activity are then considered for coordinated transferring. Generally, a timed transfer can be attractive under the following circumstances:

- A high volume of transferring exists between routes at a single point of intersection where headways on one or both routes are fairly high;

- Slack and/or layover time is available in the time schedule of secondary route(s) (circulator / crosstown) to allow buses to wait for the arrival of the primary route (radial/express) bus.

A primary route is usually a high volume radial, express, or trunk route that disperses (collects) transferring passengers to (from) the remaining service network. Typically, this route can not be purposely delayed in waiting for the arrival of a secondary route.

Monitoring timed transfer performance is accomplished through a schedule adherence check at the point of intersection of the routes. Delays to secondary routes that exceed their layover or slack time force transferring passengers from this route to miss their connection to the primary route. Their delay is measured by the lag time prior to the next primary route vehicle. Delays on the primary route cause all passengers of secondary route vehicles to be delayed, as they must wait a minimum amount of time for the arrival of the primary route vehicle.

The impact of these delays, using the passenger and schedule adherence data attained through a point check, is calculated as follows:

Passenger Minutes Delayed =
Passengers Delay + Length of Delay

The result of this calculation, passenger minutes delayed, is then compared to an established standard of acceptable delay.

3.3 BOARDING COUNTS

Boarding counts are used to establish the distribution of passenger boardings on a route, by fare category. The information can be used to determine route revenue and to assist in evaluating the fare structure.

Purpose

Boarding counts are conducted to determine ridership by fare category. The primary uses of this information are to:

- Support fare subsidization. To receive subsidy reimbursement for special fare categories -- e.g., senior citizen, school -- many systems must count passengers in these categories.

- Monitor changes in ridership by fare category on a route.

- Evaluate fare structure options.

- Investigate fare evasion.

- Determine average fare per passenger.

Procedure

Boarding counts are usually conducted by vehicle operators and provide ridership totals by fare type. The requirements for implementing a boarding count are identified below.

Preparation - Observers must be trained to readily distinguish among all fare categories. Observations and recording of data should be accomplished in close proximity to the farebox and vehicle operator in order to identify fare types.

Implementation - Boarding counts can be conducted by on-board observers but are usually administered by the vehicle operator because he generally has responsibility for monitoring fare payment. The data are frequently recorded using mechanical counters, sometimes attached directly to the farebox. Since driver recognition and recording is required, the number of fare categories is usually limited to six. The totals by fare category are typically recorded at the end of each trip.

This technique is sometimes conducted by an observer riding the vehicle. Since he has no additional responsibilities (as does the vehicle operator), he can direct his attention soley to the boarding count and can usually capture more fare categories. He can also record the data by route segment, if desired. An observer is sometimes at a disadvantage however in distinguishing the cash fare that is paid or the particular fare media that is used. The observer generally sits in the seat directly behind the driver to maximize visibility.

Electronic registering fareboxes can provide an alternative to manual recording of boarding passengers by fare category. Some fareboxes automatically record cash fare information, with verification of proper fare by the driver.

Data Collected

The number and type of fare categories vary among transit systems. Some common fare categories include:

- Full cash fare
- Full cash fare plus transfer
- Reduced cash fare
- Reduced cash fare plus transfer
- All passes and prepaid tickets
- Zone fares

A sample boarding count field sheet that includes most of these data elements is provided as Figure 3-12.

Many transit systems require more detailed information on particular passenger fare categories. This information can be collected by appropriately redefining the fare categories. Observers can usually record many more data items than drivers. This is exemplified on Figure 3-13, where ten fare categories are listed.

Typical Data Analyses

Boarding information is usually totalled by fare category and recorded at the completion of the trip. From these totals, total ridership and route revenue can be determined. The information is further used to provide route level fare usage statistics which support fare structure analyses. Several particular analytical techniques supported by boarding count data are described below.

FIGURE 3-12 -- BOARDING COUNT FIELD SHEET: SAMPLE 1

BOARDING COUNT FIELD SHEET

ROUTE ____________________ BLOCK NUMBER ____________________

DAY ____________ DATE ____________ WEATHER ____________________

OBSERVER ____________________

Route Segment		Boarding Passengers					
From	To	Full Fare	Reduced Fare	Transfer	Full + Transfer	Reduced + Transfer	All Passes

FIGURE 3-13 -- BOARDING COUNT FIELD SHEET: SAMPLE 2

BOARDING COUNT FIELD SHEET

ROUTE ______________________ BLOCK NUMBER ______________

DAY ______________ DATE ____________ WEATHER ______________

OBSERVER ______________

Stop Location	Boarding Passengers									
	Full Fare	Full Fare + Transfer	Transfer	Passes						
				Weekly	Monthly	E & H	Student	Employee	Special	+ Transfer

Revenue Monitoring - Since transit is, in most systems, a cash business, it is important to monitor revenue handling. To determine if there are revenue losses, actual route revenue as determined from revenue counts (Section 3.5) is compared with the expected route revenue calculated (resulting from the boarding count). The sequential procedure for this is to:

- Multiply the total full cash fare boardings by the fare;
- Multiply each reduced cash fare boarding by the appropriate fare and total this;
- Multiply the number of full fare plus transfer boardings by the cash fare;
- Multiply the number of reduced fare plus transfer by the appropriate cash fare and total this;
- Sum all of the above to determine the expected cash revenue; and
- Compare the expected cash revenue with the actual cash revenue.

A sample set of calculations is provided in Figure 3-14.

If the actual revenue determined from the revenue check at the completion of the trip is the same as the expected revenue that was calculated, in net, no fare loss has occurred. If discrepancies exist, as in the example, the numbers should be recalculated to insure that numerical errors were not made prior to concluding that fare degeneration actually occurred. It is also possible for actual fare revenue to exceed the anticipated amount if patrons overpay fares, although this occurs infrequently in practice.

Determination of Average Fare Per Passenger - In many transit systems, total ridership is estimated from total revenue using the statistic, averge fare per passenger. Typically, boarding count data are needed to calculate average fare per passenger. Two forms of this statistic are generally used -- average system fare per passenger and average cash fare per passenger. Each is discussed below:

The average system fare per passenger statistic is used primarily to estimate system ridership. If route revenues are known, it can also be used to allocate revenues to individual routes. The calculation of this statistic is as follows:

$$\text{Avg System Fare per Passenger} = \frac{\text{Cash + Prepayment Revenue}}{\text{Cash + Prepayment Passengers}}$$

A sample calculation of average system fare per passenger is shown on Figure 3-15.

The average cash fare per passenger statistic is used to estimate route level ridership. The calculation is similar to the above, however, only cash revenue is included:

$$\text{Average Cash Fare per Passenger} = \frac{\text{Cash Revenue}}{\text{Cash + Prepayment + Passengers}}$$

3.4 FAREBOX READINGS

The farebox reading is a running total of the cash deposited by passen-

FIGURE 3-14 -- SAMPLE CALCULATION: FARE EVASION

SAMPLE CALCULATION: FARE EVASION

FARE SUMMARY

- Full Fare 75¢
- Reduced Fare
  - Student 50¢
  - E & H 20¢
- Transfer 15¢

BOARDINGS SUMMARY

Boardings Counted (Cash Fares Only)

- Full Fare 100
- Reduced Fare
  - Student 10
  - E & H 20
- Transfers Purchased 20*

130

CALCULATION OF ROUTE REVENUE:

	Boardings	X	Fare	=	Revenue
Full Fare	100		$0.75		$75.00
Reduced					
Student	10		0.50		5.00
E & H	20		0.20		4.00
Transfers Purchased	20		0.15		3.00
	130				$87.00

ACTUAL ROUTE REVENUE: $83.00

FARE EVASION: $ 4.00

FARE EVASION RATE: 4.6%

* *Not included in total*

FIGURE 3-15
SAMPLE CALCULATION: AVERAGE FARE PER BOARDING PASSENGER

SAMPLE CALCULATION: AVERAGE FARE PER BOARDING PASSENGER

FARE SUMMARY

. Full Fare	75¢
. Reduced Fare	
– Student	50¢
– E & H	25¢
. Transfer	15¢
. Passes *(based on 10 trips per month)*	
– Weekly	$ 7.00
– Monthly	$26.00

BOARDINGS SUMMARY

. Full Fare	100
. Reduced Fare	
– Student	10
– E & H	20
. Transfer	20*
. Passes	
– Weekly	15
– Monthly	35
	180

CALCULATION OF ROUTE REVENUE:

	Boardings	X	Fare/Trip	=	Revenue
Full Fare	100		$0.75		$75.00
Reduced					
– Student	10		0.50		5.00
– E & H	20		0.20		4.00
Transfer	20*		0.15		3.00
Passes					
– Weekly	15		0.70		10.50
– Monthly	35		0.65		22.75
	180				$120.25

FARE PER PASSENGER :

Total Revenue	÷	Boardings	=	Avg. Fare
$120.25		180		67¢

* *Not included in total*

gers. A registering farebox is necessary for the application of this technique. Some registering fareboxes provide the capability to record detailed data on the number and type of fares paid as was discussed in the previous section on Boarding Counts.

Purpose

Farebox readings are generally performed to provide a transit system with daily revenue information. In particular, a farebox reading can be conducted to:

- Determine total route revenue;
- Estimate ridership; and
- Identify passengers by user group or by fare payment level (available only if the particular farebox offers this option)

Procedure

Farebox readings are relatively easy to take, requiring only that appropriate numbers on the farebox be recorded. Documentation can be conducted manually from a farebox reading, or automatically using a data probe which feeds transaction and revenue data directly to a microcomputer. Farebox readings are routinely recorded during vehicle servicing at most transit systems.

Preparation - The only preparatory requirement is that the observer, usually a driver or supervisor, clearly understands how to read the farebox and accurately record the information.

Implementation - Actual conduct of this technique requires the recorder to read the farebox transactions and cash contents. At a minimum, this involves recording the value of all coins deposited and total transactions. Depending on the farebox technology, dollar bills, tickets, and even prepayment summaries may also be captured.

Farebox readings are often taken as part of the service line operation as the bus pulls in off the street. The reading can be made by security or supervisory staff, the vehicle operator, or other service personnel. Readings can be taken manually, or via an electronic data probe, depending on the specific equipment in use.

At a minimum, a farebox reading should be made at the beginning and end of each vehicle (i.e., block) assignment. It can also be taken at the end of each drivers run, or for particular time or trip intervals. Where buses are interlined onto other routes and/or driver replacements are made on the street, interim readings should be considered. Sample forms for a driver to read total coins and currency after each trip or after each operating period are provided as Figures 3-16, 3-17, and 3-18, respectively.

Data Collected

The data items obtained through a farebox reading are:

- The coin value deposited
- The paper currency value deposited
- Boardings by fare category (available only if certain farebox technologies are employed)

It should be realized that the registering capabilities of the

FIGURE 3-16 -- TERMINAL FAREBOX READING SHEET

FAREBOX READING FORM

DATE ____________ TERMINAL ____________ FORM NUMBER _____ OF _____

Vehicle Block	Operator's Employee Number	Time of Reading		Totals				Subtotal by Fare Category						Initial Here
				Coin		Currency		Adult	Student	E/H	Transfer	Pass	Free	
Form Total														

FIGURE 3-17 -- TRIP FAREBOX READING FIELD SHEET

FAREBOX READINGS – TRIP

ROUTE ______________________ DATE ______________________

BLOCK NUMBER ______________________ WEATHER ______________________

DAY ______________________ FAREBOX NUMBER ______________________

Trip Number	Beginning Reading		Ending Reading	
	Coin	Currency	Coin	Currency

Daily Total
(for office use)
Coin ______________________
Currency ______________________
Total ______________________

Operator Signature ______________________

Employee Number ______________________

FIGURE 3-18 -- TIME PERIOD FAREBOX READING FIELD SHEET

FAREBOX READINGS – TRIP PERIOD

ROUTE ______________________ DATE ______________________

BLOCK NUMBER ______________________ WEATHER ______________________

DAY ______________________ FAREBOX NUMBER ______________________

Operating Period	Time of Reading	Beginning Reading		Ending Reading	
		Coin	Currency	Coin	Currency
A.M. Peak					
Midday					
School Peak					
P.M. Peak					
Evening					
Owl					

Operator Signature ______________________

Employee Number ______________________

Daily Total
(for office use)

Coin ______________________

Currency ______________________

Total ______________________

farebox vary from system to system. At a minimum, they record the value of coins deposited. Those with separate bill compartments usually tally currency and tickets also. Some fareboxes can be pre-programmed to accept the cash amount equivalent to an adult full fare as valid and record the number of transactions in this category automatically. Transit systems generally also identify the last driver of the bus and the time of reading as input to payroll and audit procedures.

Typical Data Analyses

Farebox readings are commonly taken to determine total route revenue or to estimate revenue passengers. The methods used to calculate these are given below.

Route Revenue Calculation - The determination of route revenue is a simple process. Farebox readings taken at the beginning of the assignment are simply subtracted from those taken at the end.

Revenue Passenger Estimation - Revenue passengers can be estimated by dividing the calculated route revenue by the average cash fare per passenger. While this result may not be reliable enough to invoke service modifications, it does provide a simple means to detect or monitor unexpected ridership fluctuations on a daily basis. To show the simplicity of the process, an example is provided in Figure 3-19. The average systemwide fare used is 60¢.

This approach requires an estimate of the average fare per passenger which can be attained through a boarding count analysis (Section 3.3).

Revenue Trend Analysis - Trends in fare revenue can provide a general indication of the health of the system

FIGURE 3-19
EXAMPLE OF REVENUE PASSENGER ESTIMATION

	Beginning Reading		Ending Reading			
Trip	Coin	Currency	Coin	Currency	Net Rev.	Rev. Passengers
121	0.00	0.00	8.00	1.00	9.00	15
122	8.00	1.00	17.50	3.00	11.50	19
123	17.50	3.00	41.25	10.00	30.75	51
124	41.25	10.00	70.25	14.00	33.50	56
125	70.75	14.00	132.00	20.00	67.25	112
			TOTAL		152.00	253

or a particular route. Revenue trends can be examined to support fare pricing and policy decisions, or can indicate a need to re-evaluate service. Trends can be examined by time period or even by trip to identify areas which can be improved.

3.5 REVENUE COUNTS

Revenue counts are conducted to identify how much money the transit system takes in through the farebox each operating day. Revenue counts can be made for the system as a whole as well as individual divisions, routes, blocks, runs or trips. The information is used to support auditing and financial analyses.

Purpose

The farebox is the primary source of system revenue. The revenue count identifies how much money the system took in each operating day and serves as a final and accurate check of farebox intake. The information attained from revenue counts is used to:

- Determine total revenue
- Estimate ridership

Procedure

Revenue counts require the sorting and counting of all cash received through the farebox. This technique is used routinely at most transit systems.

Preparation - The large amount of money handled through revenue counts dictates that strict security procedures be developed and followed closely. Adherence to these should be monitored continually.

Implementation - Individual farebox vaults (or cashboxes) typically are pulled or vacuumed at the end of the operating day as each vehicle moves through the service lane at the garage. The full vaults are either emptied at this point into a larger receiving vault, or transported as is by security personnel to the counting room.

At the counting room, all individual or receiving vaults are emptied into the special equipment by the counting room personnel. Paper is separated from coins which are then sorted and counted by denomination. A total deposit is prepared and transported from the transit system's counting room to the local bank by armored truck. Each day's revenue count is usually entered into a ledger wherein daily and monthly totals are recorded (Figure 3-20). A sample monthly report, provided as Figure 3-21, shows both tabular and graphic formats for presenting the fare revenue information.

Disaggregate forms of the data can also be attained. Revenue from a particular route or block can be separated throughout the process and counted apart from system revenues. Where interlining occurs, however, this is more difficult to accomplish and would necessitate several pulls of the vaults throughout the operating day. Security and cost considerations often limit this application.

Data Collected

The primary data item collected from the revenue count is total daily system revenue from the farebox. As shown below however, revenue can be determined for different degrees of aggregation.

Delineation	Revenue	Time Period
System	total	day
Division		
Route	coins/currency	periods

Typical Data Analyses

The revenue data collected through this technique supports several types of analyses, as discussed below.

Single Vault Revenue Count - Single vaults can be totalled separately as an auditing function to check on the accuracy or security of registering fareboxes. Since individual farebox vaults are usually dumped into a large vault with other farebox revenue for sorting and counting, auditing of individual vaults requires these to be separated.

Revenue Passenger Estimation - An estimate of revenue passengers can be made by dividing the totalled vault revenues by the average fare per passenger. This result provides a simple means to detect or monitor unexpected ridership changes on a daily basis.

A sample calculation of revenue passenger estimation has been provided previously in Section 3.4, on page 25.

FIGURE 3-20 -- DAILY REVENUE RECORDING SHEET

DAILY REVENUE SUMMARY MONTH ____________

Date	Coin		Currency		Total	
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						
			Monthly Total			

FIGURE 3-21 -- SAMPLE REVENUE SUMMARY BY MONTH

REVENUE TREND REPORT

Month	1983 Revenue	1982 Revenue	Variance	Percent Change
January				
February				
March				
April				
May				
June				
July				
August				
September				
October				
November				
December				
Total				

The calculation of average fare per passenger was detailed in Section 3.3 on page 21.

Revenue Trend Analysis - Trends in fare revenue can provide a general indication of the health of the system or of a particular route. Revenue trends can be examined by time or even by individual trips. Changes in trend direction can indicate a need to re-evaluate service, or can support fare pricing and policy decisions.

3.6 SPEED AND DELAY

Speed and delay studies are used to investigate points along a route which may be contributing to impedances or delays in revenue service. This technique usually requires the timing of vehicle flow through congested intersections or traffic bottlenecks.

Purpose

Speed and delay studies are made to:

- Investigate unusual delays which might be causing schedule adherence difficulties; or
- Explore opportunities to streamline service.

Procedure

The conduct of a speed and delay study requires that queues are observed and delays be recorded. The expected problem areas should be identified prior to implementation of this study.

Preparation - Locations along a route expected to be causing the vehicle delays need to be identified. This is frequently accomplished through a "Running Time" study (Section 3.7) or from specific driver complaints.

Observers should be trained on the procedures for timing vehicles (including the use of a stop watch) and instructed on how queues are defined and represented. Queue identification is often misunderstood and can lead to inconsistent data and incomparable results. Following observer training, a 10- or 15-minute pretest can be made to insure familiarity with the procedures.

Implementation - An observer is stationed at the curb or a point where the intersection or congested area can be best observed. The observer times the delays or queues of passing transit vehicles with a stop watch and records this information on the field sheet. For busy intersections and monitoring vehicles in more than one direction, an additional observer may be necessary -- one observer would monitor the vehicles while the second recorded the information.

Data Collected

Two types of delays are commonly investigated -- general traffic signal delays and left turn delays. For general traffic signal analyses, the following data are collected:

- The number of vehicles by type waiting (in queue) at the stop light at the beginning of the green phase;
- The number of vehicles by type passing through the intersection during the green phase; and
- The number of vehicles by type waiting at the stop light at the end of the green phase.

These data items are recorded for each signal cycle as shown in Figure 3-22.

FIGURE 3-22 -- SAMPLE TRAFFIC SIGNAL DELAY FIELD SHEET

TRAFFIC SIGNAL DELAYS FIELD SHEET

INTERSECTION ______________________ ROUTE(S) ______________

DAY ______________ DATE __________ WEATHER ______________

START TIME __________ STOP TIME __________ OBSERVER ______________

Cycle Number	Vehicles Waiting at Beginning of Green Light			Vehicles Through Intersection			Vehicles Waiting at End of Green Light		
	Autos	Bus	Other	Autos	Bus	Other	Autos	Bus	Other
TOTAL									

FIGURE 3-23 -- SAMPLE LEFT TURN DELAY FIELD SHEET

LEFT TURN DELAYS FIELD SHEET

INTERSECTION ____________________ ROUTE(S) ____________

DAY ____________ DATE ____________ WEATHER ____________

START TIME ____________ STOP TIME ____________ OBSERVER ____________

Delay	Transit		Autos	
	Vehicles	Passengers	Vehicles	Occupants

The cycles can be numbered or the starting time is recorded. It should be noted that the "green phase" data includes the green and yellow light sequences.

Left turn delay checks are used to record the amounts of transit vehicle and passenger car delays that result from other vehicles making left turns off of the major street. The data that is collected may include:

- Duration of delay
- Number of transit vehicles delayed
- Number of automobiles delayed
- Number of transit passengers delayed
- Number of automobile occupants delayed

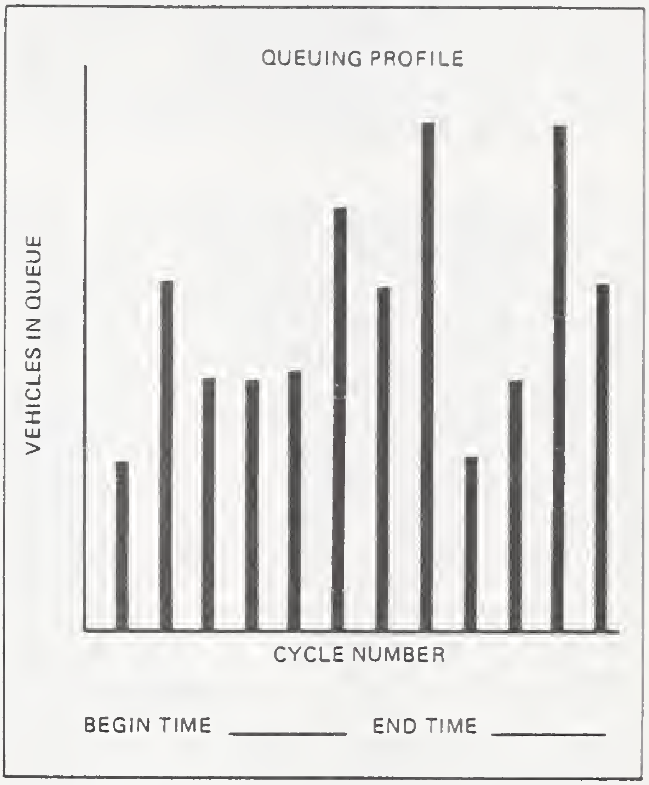
A sample data collection field sheet for left turn delay applications can be seen on Figure 3-23.

Typical Data Analyses

The traffic delays experienced by vehicles and total passengers in revenue service are generally evaluated with this technique. Intersection design, traffic signal phasing, and bus stop location are often causes for the delays. The tools used to explore these are discussed below.

Signal Delay Queueing Profile - A signal delay queueing profile is often prepared to examine schedule adherence difficulties. The profile graphically illustrates (on Figure 3-24) the queueing experienced by vehicles during each particular time period reviewed.

FIGURE 3-24
SIGNAL DELAY QUEUING PROFILE



If queue length is steadily increasing over the time period, the vehicle flow volume may be exceeding the design volumes of the intersection and excessive delays can be expected. Consideration then might be given to improvements in signal phasing, bus stop location, and route alignment.

Signal Cycle Evaluation - A second approach to investigating unusual intersection delays is to evaluate the green cycle time of the traffic signal. If vehicles wait at the intersection for more than one complete cycle -- green-to-yellow-to-red-to-green -- the intersection may be over capacity or the phasing sequence (e.g., duration) may be inappropriate. To determine if either of these conditions

is occurring, the total number of vehicles that pass through the intersection are subtracted from the total number of vehicles that were waiting at the beginning of the green phase. The results will be greater than zero if the buses must wait more than one cycle.

Average Delay Calculation - Left turn delay analyses are best conducted by determining the average delay experienced per vehicle by vehicle type. This is done by simply dividing the number of vehicles by the total delay experienced. The resulting average delay for transit can then be compared to the average deviation in schedule adherence that has been observed (through point checks or running checks) to assess how this intersection is contributing to poor on-time performance. For example, if the average vehicle on a route is 5 minutes late, and the calculated average intersection delay for transit vehicles is three minutes, the delay at this intersection is the major problem on this route.

Passenger Delay Determination - Total passenger delays is an important consideration when contemplating service alignment changes. This is calculated by multiplying the number of passengers per vehicle (determined possibly through a simultaneous point-check) by the time the corresponding vehicle was delayed. Summing over all vehicles yields the total passenger minutes delayed on the route or routes.

Bus Stop Location Assessment - Bus stop relocation analysis is an additional use of speed and delay studies. If transit vehicles are continually observed to arrive at an intersection during a green light but encounter a red light after discharging and picking-up passengers, a far-side bus stop might be considered. Examining the traffic lights encountered by vehicles serves only as a screen for more detailed stop location analyses, however. Safety must also be considered.

3.7 RUNNING TIME STUDY

In a running time study, the average bus travel time over designated route segments is determined by time period. The information is used for operations planning, particularly service scheduling.

Purpose

Running time studies are conducted primarily to support scheduling decisions and investigate service delays. In particular, this technique is used to:

- Adjust revenue service schedules to better reflect on-street conditions
- Cut schedules for new service
- Identify delays along a route

Procedure

Running time studies are very simple to conduct, requiring that travel time be charted by location along a route. This is usually accomplished through a "trail check". Trail checks generally require an observer to travel in a second vehicle behind the bus and record the travel time at specific locations (e.g., bus stops). The particular requirements for conducting running time studies are discussed below.

Preparation - Routes or corridors to be studied must be identified and delineated into route segments. Segmentation can be done by geographic

boundaries, by major intersections, or even by bus stop.

Observers are required to monitor vehicle travel over the route and document vehicle delays. Observers should be trained in categorizing delays to conduct this successfully and consistently. The following breakdown can serve as a guide to defining vehicle delays:

- Slow Starts - number of instances of slow acceleration in attempt to consume excess running time
- Slow Stops - number of instances of slow braking in attempt to consume excess running time
- Slow Downs - number of instances of marked reductions in speed to avoid collisions, etc.
- All Stops - number of stops for passengers, traffic, etc.

Instructions to field observers should also include a list of the vehicles which each is to observe, a list of the points on the line at which the running time is to be recorded, an explanation of the symbols to use for recording slow operation and unusual delays, and whether the arrival or departure time at the listed locations are to be recorded. It is also useful to drive over the route prior to data collection to familiarize the observer with all designated locations.

Implementation - Vehicle running times are usually recorded by an observer in a second vehicle, but can also be collected by an observer on the bus. The former is the most frequent method used as it allows for discretion in conducting the study. The bus driver probably will not modify normal driving patterns if he is unaware of the study. This allows observations of the individual operator's driving performance, as well.

The observer in a trailing passenger car can categorize and record vehicle movements. One observer is usually sufficient as his driving pattern corresponds to the bus' and he can therefore record bus stoppages while he is stopped. If the study is conducted on express routes, or if travel times are to be taken at locations where the vehicle does not stop, a second observer may be needed -- one to time and record and the other to drive.

Data Collected

The key data item collected in a running time check is arrival times at key locations. Delays and their causes are frequently documented also, as illustrated on the two sample forms provide in Figures 3-25 and 3-26. Codes or symbols can be used to indicate slow operations and identify the type of delay. This simplifies and expedites recording procedures. The speed and delay factors could include the following conditions:

- Killing Time
- Slow Moving Traffic
- Delayed Bus Ahead
- Road Repair
- Road Condition
- Vehicle Interference
- Starter Held Vehicle
- Traffic Lights
- Weather

Slowness and stopping are counted by occurrence also. These can be assigned to one of the four categories

FIGURE 3-25 -- RUNNING TIME FIELD SHEET: SAMPLE 1

RUNNING TIME CHECK FIELD SHEET

Sheet ____ of ____ Sheets

WEATHER ______________________ DATE ____________

LINE CHECKED ____________ DAY ____________

TIME ______ AM

FROM ____________ TO ____________

______ PM

BLOCK NO. ____________ VEHICLE NO. ____________

From	Time	To	Time	Time Used	Slow Starts	Slow Stops	Slow Downs	Total Stops
Delay Causes and Comments							Max. Passenger	
Delay Causes and Comments							Max. Passenger	
Delay Causes and Comments							Max. Passenger	
Delay Causes and Comments							Max. Passenger	
Delay Causes and Comments							Max. Passenger	

*Show Leaving Time at Starting Terminal and Arriving Time at all Other Points.

FORM NO. ______________________ OBSERVER ______________________

FIGURE 3-26 -- RUNNING TIME FIELD SHEET: SAMPLE 2

RUNNING TIME CHECK FIELD SHEET

Sheet ______ of ______

LINE ____________ BLOCK ____________ DATE ____________

VEHICLE ____________ OPERATOR NO. ____________ DAY of WEEK ____________

WEATHER ____________ OBSERVER ____________

From	Time	To	Time	Time Used	Slow Starts	Slow Stops	Total Stops	Traffic Delay Secs.	Max. Pass.	Remarks
1	2	3	4	5	6	7	8	9	10	11
A										
B										
C										
D										
E										

Instructions:

Col. 1 – 4 Use seperate lettered space for each part of the line, filling the sheet from top to bottom in one direction and bottom to top in other direction.

Col. 5 Compute in the office.

Col. 6 – 8 Tally these columns.

Col. 9 List each delay over 30 seconds due to traffic or signals.

Col. 10 List maximum number of passengers on vehicle and under remarks show point of occurrence.

Col. 11 List any other important unusual circumstances.

discussed previously (see procedures) and listed below:

- Slow Starts
- Slow Stops
- Slow Downs
- All Stops

Consistent categorization should be stressed to observers.

Typical Data Analyses

Running time study results may either confirm the appropriateness of existing schedules (e.g., from an adherence perspective) or suggest possible areas for revision. Likewise, complaints of delays may be investigated to determine whether the problem is chronic or an infrequent occurance. Three sequential steps are used to evaluate study results:

- Unreasonable data resulting from unusual or exceptional incidents (e.g., fire along the route, major accident etc.) are screened out.

- Running times, recorded by particular location, are summarized for all vehicles observed, usually by 30- or 60-minute time periods.

- Average trip time by route segment by time period is then determined by dividing the total travel time by the number of vehicles.

The average running times calculated reflect a trip making the average number of stops and slow downs, carrying a normal load, and experiencing a typical amount of traffic interference. The extent to which these vary from the current running times used in the schedules will suggest possible areas for revision.

A graphical approach can be used to review running times. The range of running times scheduled for trips throughout the operating day are plotted similarly to the downtown route illustrated in Figure 3-27. In the example, a trip that takes eight minutes at midnight takes 13 minutes at noon.

3.8 TRANSFER COUNTS

Transfer counts are used to identify the major route interchanges being made by passengers. They are used to evaluate the directness of existing routes and opportunities for through-routing and/or improved schedule coordination (e.g., pulse points or timed transfers).

Purpose

Transfer counts help to define the trip-making patterns of a transit system's riders. By retaining, sorting, and counting transfer coupons for a given operating day, it is possible to determine:

- The daily transfer activity among all routes; and

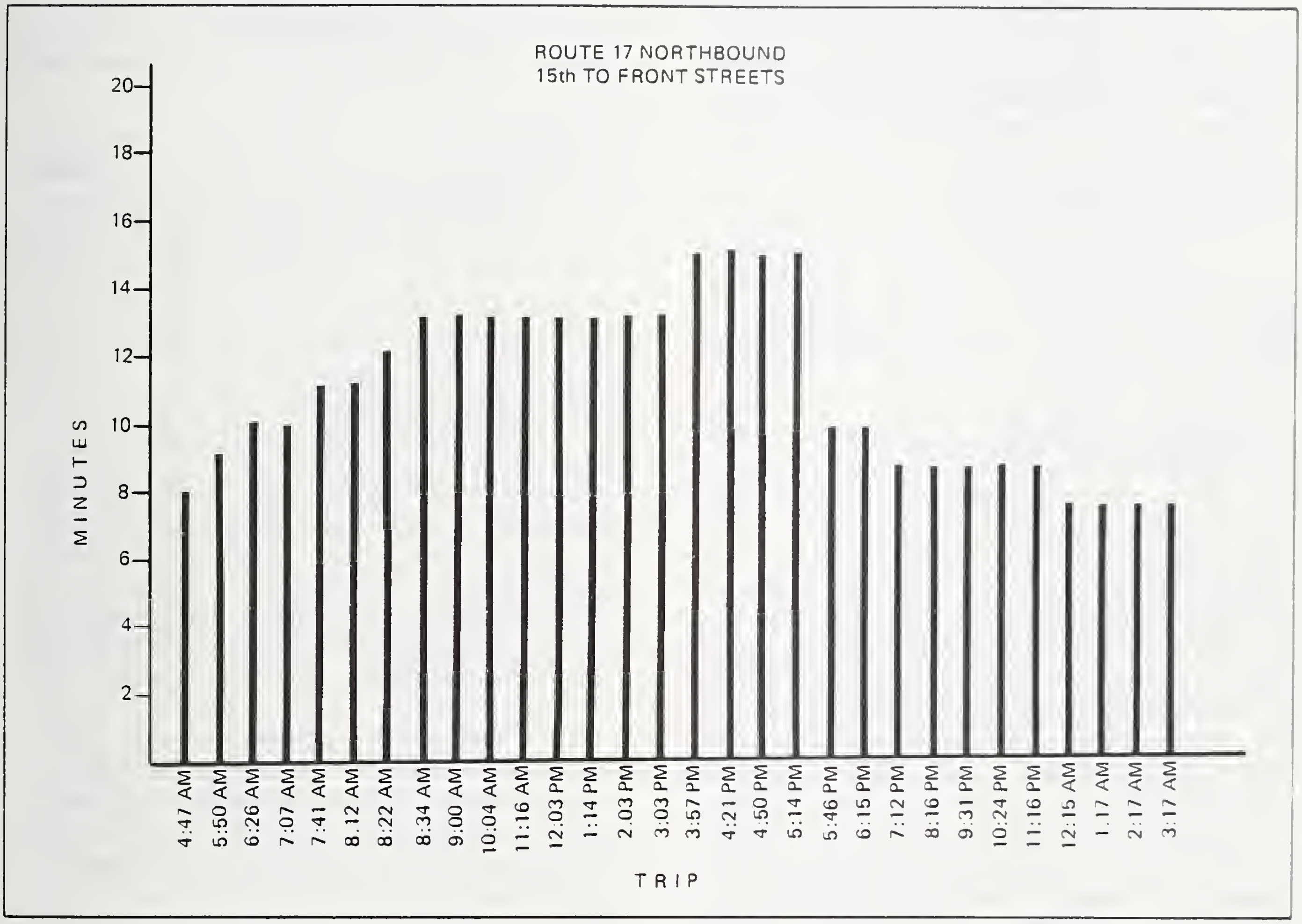
- The percentage of passengers who transfer.

Procedure

Transfer counts identify the number of passengers using more than one route to complete their trip. The steps required for this study are provided below.

<u>Preparation</u> - The conduct of a transfer count generally requires that transfer tickets or coupons identify

FIGURE 3-27
SCHEDULED RUNNING TIME ANALYSIS



the route of origin. These are done by using route-specific coupons or by using tickets which allow drivers to "punch" or tear appropriate route identification information.

Drivers should be provided with collection bags or envelopes to store transfers from boarding passengers. If possible, the transfers should be stored in a separate envelope after each trip. Where the use of envelopes is not possible, the drivers are instructed to insert the transfers into the farebox. In all cases, the drivers should be reminded to retain the transfers as input for the study.

Implementation - Transfers, traceable to route of origin, are distributed to passengers as usual. This is typically done by the driver for boarding passengers who request a transfer and have paid the appropriate fare. Drivers of second vehicles collect and store the transfers from boarding passengers. At the end of the operating day, the transfers are turned in. Operations personnel or supervisory staff then sort and talley the transfers by route of origin and destination. If vehicles are interlined between routes, the transfers distributed and received by this operator should be separated by route.

Data Collected

The fundamental result of a transfer count is a summary of passenger interaction among routes (i.e., the number of passengers transferring between any two routes is documented).

Typical Data Analyses

The method typically used to analyze transfer count data is a summary transfer matrix. The procedure is supported by a numerical example and discussed below.

Summary Transfer Matrix - The transfers are sorted by route of origin and destination, and are then tallied and recorded in a matrix format. Originating routes are represented as rows of the matrix, and receiving routes as columns. Summing across the rows yields the total number of transfers from any given route, while summing down the columns provides the route totals for receiving transferring passengers, as shown in the sample matrix provided as Figure 3-28. A review of this matrix shows that transfers, with the exception of the movement between Routes 2 and 5, are relatively uncommon. This low transfer activity probably indicates that the existing service is reasonably direct for existing patrons. In general, if most passengers (e.g., 80 percent or more) can reach their destination without transferring, then the transit system's route planners may have designed an effective route network from a patron convenience standpoint.

Conversely, Routes 2 and 5 exhibit high transfer activity -- 156 transfers from Routes 2 to 5; 179 transfers from Routes 5 to 2. This suggests that the service for these patrons is not ideal and that opportunities for improvement should be explored. Three possible options are identified below:

FIGURE 3-28

SAMPLE OUTPUT FROM TRANSFER COUNT
(Daily Transfer Activity)

	Route (From) / Route (To)	1	2	3	4	5	6	Total
From	1	2	27	14	96	27	3	169
	2	32	–	23	1	156	15	227
	3	15	21	1	9	29	47	122
	4	89	–	11	2	42	21	165
	5	29	179	28	42	–	3	281
	6	2	16	42	20	2	–	82
	Total	169	243	119	170	256	89	1,046

- Through-routing the lines so that the need to transfer is eliminated; or

- Reviewing schedules for the two routes at the point where they intersect to assure that transfer times are coordinated (thus limiting wait times); or

- Implementing timed transfers, particularly if the transfer activity is bi-directional throughout the day.

Decisions to adjust route pairings or schedules as a result of transfer count data should consider the extent of current transfer activity. Also origin and destination survey information may supplement this analysis by providing information on current non-transit trips.

3.9 TRANSIT VEHICLE PASSENGER STOPS

Transit vehicle passenger stop studies review loading patterns at

specific stops, providing input to decisions on stop size and location. A physical inventory of each stop is conducted and peak hour operations are monitored.

Purpose

A transit vehicle passenger stop study is conducted to:

- Provide a physical inventory of each bus stop;
- Evaluate specific operating problems or capital programs.

The results of the study could suggest that a bus stop and the amenities located at that stop be enlarged, redesigned or relocated. Operational changes which could also be supported include scheduling and routing, stop sign placement and traffic signal timing.

Though the focus of this study is generally different, it can collect some data which overlap that collected with other techniques. The study can also be used to collect on-off counts, schedule adherence information, and transfer counts all for a specific location.

Procedure

The conduct of a transit stop passenger study is accomplished through a physical inventory of each site and the documentation of actual operations and curbside amenities (e.g., benches or shelters). The entire system can be reviewed through this process, or particular routes, general areas (e.g., the central business district), or single stop locations. Particular methods and requirements of this technique are highlighted below.

Preparation - Inventory and data sheets should be preceded by stop name or number. A data file can then be kept by route or street for later reference. Observers should be familiar with the layout of the intersection and the stop characteristics. A pretest can be used to train observers. Also, data collectors should be equipped with both a wristwatch and a stopwatch.

Implementation - A transit stop passenger study is conducted in two distinct parts. First, a physical inventory is performed. Observers document the characteristics of each stop, amenities, and the immediate area around the stop.

The second part of the technique is observation. Data collectors monitor and record passenger and vehicle activity at the intersection. Vehicle dwell times are recorded as are passenger boarding and alighting patterns (e.g., direction of departure). A verification check on the physical inventory information is also performed. Field observers would draw a diagram of the intersection and stop on the reverse side of the form. Any signs, curb parking benches, shelters, and other attributes would be noted by type and location. This should be done either before or after actual collection and be checked against the intersection inventory file.

This technique is generally conducted during the peak period to document highest use conditions. Usually one observer at each stop is sufficient, however, this is dependent upon the physical attributes of the intersection.

Data Collected

The field reconnaissance data that are usually collected include:

- Location of stop
- Type of stop
- Size - length and width
- Pavement condition of the waiting area
- Sign inventory
  - bus stop
  - no parking
- Safety features
- Traffic signals
- Curb parking
- Amenities

A sample field inventory sheet is provided on Figure 3-29. A blueprint of the intersection may help in site documentation.

Operational data which are captured include:

- Number of passengers using a stop during rush hour;
- Delay experience in seconds by cause (e.g., interference);
- Vehicle dwell times; and
- Passenger transfer activity.

A field form for collecting the first four data items is provided as Figure 3-30 (passenger activity is discussed later). Physical characteristics such as size and stop type are reported at the top of the form for use in subsequent analyses. More detailed information could be collected on passenger activity at the stop emphasizing transfer patterns and the direction in which alighting passengers walk as shown in Figure 3-31.

FIGURE 3-29

INVENTORY OF TRANSIT STOPS

TRANSIT VEHICLE PASSENGER STOP PHYSICAL INVENTORY

Location ____________ Code No. ____
Jurisdiction ____________
Routes Using Stop ____________

1. Location: on ______ street at ______ street on ______ side.

2. Type of stop: ☐ near-side ☐ mid-block ☐ far-side ☐ other

3. Size: Length ______ width ______

4. Type and condition of pavement markings, curb markings, and signs (diagram on reverse side):
____
____

5. Pavement surface and condition of the waiting area at the stop: ____________
____

6. Types and condition of safety features: ______
____

7. Type, condition, and operation of traffic control devices at or near stop (diagram on reverse side): ______
____
____

8. Surrounding curb space use (diagram on reverse side):
____
____

9. Amenities present: ☐ shelter ☐ bench ☐ telephone ☐ newspaper box or stand ☐ other ______

Observer ____________

Date ______ Time ______

FIGURE 3-30 -- VEHICLE STOP FIELD SHEET

VEHICLE STOP FIELD SHEET

LOCATION ______________ CODE NO. ______________

SIZE ______________ TYPE ______________

DATE ______________ TIME ______________ AM PM

DAY ______________ WEATHER ______________

Route	Block	Vehicle	Time		Interference To Use				Passengers	
			Arrival	Departure	Type	Pulling In	Pulling Out	Time Delay	On	Off

Use Symbol To Denote Types Of Interference :

P- illegally parked car S- standing car A- another transit vehicle T- traffic signal

FORM NO. ______________ OBSERVER ______________

FIGURE 3-31 -- PASSENGER ACTIVITIES AT TRANSIT STOPS

PASSENGER STOP FIELD SHEET

LOCATION ____________________ CODE NO. ____________________

DATE ____________________ TIME PERIOD ____________________

DAY ____________________ WEATHER ____________________

Route	Block	Time		Passengers		Transfers to	Walk			
		Arrival	Departure	On	Off		E	W	N	S

FORM NO. ____________________ OBSERVER ____________________

Typical Data Analyses

Information from this study can be analyzed in many ways. For example, the total number of vehicles at the stop at any one time could be calculated. If their combined length exceed the stop length, the need for additional curb space would be identified. If total passengers exceed sidewalk or shelter capacity, provisions for additional stop length or shelters could be considered. Similarly, the system could consider dividing up a large stop into assigned stops by route. This would distribute passengers more evenly along the curb length. If alighting passengers show a tendency to walk in a dominant direction, this may suggest an opportunity to reroute the bus onto the next parallel street.

Finally, the analysis of causes of bus and/or patron interference could suggest the need for several operating modifications (e.g., enforcement of no parking provisions or a traffic signal preemption program). Where many vehicles are encountering interference from turning automobiles or traffic signals, relocation from a near-side to a far-side stop location could be considered as well.

CHAPTER 4 -- SUMMARY OF TECHNIQUES

Effective operator planning and monitoring requires accurate and timely information. The development of a data collection program to collect this information generally requires following several sequential steps:

- Identify Information Needs - At the onset of program development, the analytic process and data requirements should be clearly defined.

- Select Data Collection Technique - The data collection technique or techniques should be selected based on the specific data requirements and available resources.

- Develop Data Collection Forms - Standardized data collection forms should be prepared to capture all pertinent data elements.

- Establish Administrative Plan - The procedures and resources needed for study implementation should be defined, and a study schedule established.

- Conduct Training Program - Observers should be trained in all aspects of their data collection responsibilities, including use of forms, equipment and procedures. Written instructions are helpful, as they can be referred to as questions arise.

- Implement Program and Quality Control - Periodic performance reviews should be made during the actual data collection step to verify accuracy and identify potential problems. A pre-test may be appropriate to determine the effectiveness of the technique before actual data collection begins.

Each of the data collection techniques discussed in this report is designed to collect several specific data elements, although overlap in capabilities does exist. A brief summary of the techniques follows:

- Ride Checks - an observer generally rides each subject vehicle and records passenger boardings and alightings by stop. Vehicle pull-in, pull-out and dwell times can also be recorded by stop.

- Point Checks - an observer usually stands at a particular stop along a route and counts the number of passengers on board each vehicle as it reaches that point. Schedule adherence and dwell time data can be recorded for each vehicle at the specific stop.

- Boarding Counts - the operator typically counts the number of passenger boardings by fare category over an entire route. An onboard observer may be used if the data requirements warrant.

- Farebox Readings - farebox readings may be taken periodically by the driver, or at the end of the day by servicing personnel, to determine route revenue and transactions (depending on farebox capabilities).

- Revenue Counts - revenue receipts are counted to determine the amount of cash fares received on a given route, day or other period. Most counts are performed in the revenue counting room although some may be taken from registering fareboxes.

- Speed and Delay - an observer usually stands at a problem intersection and monitors traffic and signal related delays to revenue vehicles in service.

- Running Time Study - an observer typically rides a transit vehicle, or follows it in another vehicle, and records travel time between stops and dwell time at stops.

- Transfer Counts - the operator generally collects transfer coupons from patrons, which are later counted to ascertain transfer activity between routes. The transfer coupons should identify the route of origin.

- Transit Vehicle Passenger Stops - an observer typically stands at a particular bus stop and records passenger volumes and activity. An inventory of amenities and stop layout is frequently part of this study.

These techniques can be used separately or in concert, depending on the specific needs of the transit system. Also, the conduct of one study may suggest the need for another study (e.g., a ride check may suggest the need for a running time study).

REFERENCES

References which support or compliment this document include:

- American Transit Association, Manual of Transit and Traffic Studies, Washington, DC, 1947 - the previous transit data collection manual also includes traffic studies.

- Booz, Allen & Hamilton Inc., Introduction to Transit Operations Planning, Washington, DC, 1982 - a four-day seminar for entry-level planners, sponsored by UMTA and presented in selected cities across the United States.

- Multisystems, Inc., and ATE Management & Service Co, Bus Transit Monitoring Manual, Washington, D.C., 1981 - a two-volume manual sponsred by UMTA, covering development of a data collection program as well as detailed guidance in sampling.

- Vuchic, Vukan, Transit Operating Manual, prepared for Pennsylvania Department of Transportation, Harrisburg, PA., 1978 - an UMTA sponsored manual presenting basic methods and techniques of transit planning operations.

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